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METHOD AND APPARATUS FOR PRODUCING OZONE

TECHNICAL FIELD

This invention relates to a method and apparatus for producing ozone.

BACKGROUND ART

A known method for producing ozone includes the steps of passing oxygen at 1 atmosphere and 25°C through concentric metallised glass tubes to which low-frequency power at 50-500 Hz and 10-20 kV is applied. Due to the relatively slow change in potential (5kV per millisecond), a corona or silent electric discharge is maintained between the electrodes. A disadvantage of this method is that energy is lost in the form of heat, and a relatively low yield ratio of ozone is achieved.

OBJECTIVE OF THE INVENTION

It is accordingly an object of the present invention to provide a method and apparatus for producing ozone with which the aforesaid disadvantage may be overcome or to provide a useful alternative to the known method.

SUMMARY OF THE INVENTION

According to the invention there is provided a method of producing ozone comprising the steps of generating intermittent bursts of corona discharge in an electrode region, and passing oxygen-containing fluid through the region.

thereby to cause ionization of the oxygen.

The intermittent bursts may be generated by generating a changing electric field in the region by energising the electrode with intermittent voltage pulses having a slope of at least 2kV/100ns, the field having a peak value of at least 2kV per millimetre. In this specification, the word "slope" is used to denote the slope between 30% and 70% of the peak to peak value of the pulse.

Preferably, the peak value is at least 3kV per millimetre and the slope is in the order of 3kV/10ns.

Each voltage pulse preferably has a pulse width of less than 100ns.

The bursts may be discrete bursts.

The invention also includes within its scope apparatus for producing ozone comprising:

- a housing defining a passage for a fluid comprising oxygen;
- an electrode disposed adjacent the passage; and
- pulse generating means connected to the electrode,
- the pulse generating means being operative to generate a changing electric field by generating a train of voltage pulses

each having a slope of at least 20kV/100ns.

The electric field has a peak value of at least 3kV per millimetre.

Each voltage pulse preferably has a pulse width of less than 100ns.

The pulse generating means may comprise a self-oscillating circuit.

The self-oscillating circuit may comprise a field effect transistor (FET) and a switch circuit therefor, the switch circuit comprising charge storage means; switching means connected between the charge storage means and a gate of the FET; the switching means being operative to deposit charge from the storage means onto the gate, thereby to improve a rise time of a signal in a drain-source circuit of the FET.

The charge storage means may comprise a capacitor and the switch means may comprise a SIDAC.

The electrode may be connected to a secondary winding of a transformer, a primary winding of the transformer being connected in the drain-source circuit of the FET.

The passage may extend between an inlet to the housing and an outlet

therefrom.

The electrode may be an annular electrode disposed in the housing and the passage may extend through a clearance defined between the electrode and an annular ridge in the housing.

The housing may be a metal housing, the housing may be connected to the secondary winding of the transformer and an insulating carrier for the electrode may be mounted on shoulder formations in the housing.

In another embodiment the housing may be of an electricity insulating material, the electrode may be disposed circumferentially on the outside of the housing and a second electrode also connected to the secondary winding may be provided spaced from an inner wall of the housing, to define the passage between the second electrode and the inner wall.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described further, by way of example only, with reference to the accompanying drawings wherein:

figure 1 is an exploded perspective view of apparatus according to a first embodiment of the invention for producing ozone;

figure 2 is an exploded perspective view of a closure and electrode

assembly of the apparatus of figure 1;

figure 3 is a perspective view of the closure and electrode assembly of figure 2 when assembled;

figure 4 is a schematic representation of an electronic circuit used to generate a train of voltage pulses that is applied to the electrode assembly of figures 2 and 3.

figures 5(a);(b);(c); and (d) are voltage waveforms against a first time scale at points a, b, c, and d in figure 4;

figures 6(a);(b);(c); and (d) are the same wave forms against a larger time scale;

figure 7 is a cross-sectional view on line VII in figure 3;

figure 8 is a partially broken away perspective view of apparatus according to a second embodiment of the invention for producing ozone; and

figure 9 is a cross-sectional side view of a central portion of the apparatus of figure 8.

DESCRIPTION OF A PREFERRED EMBODIMENT OF THE INVENTION

Referring to figure 1, apparatus according to a first embodiment of the invention for producing ozone, is generally designated by reference numeral 10.

The apparatus 10 includes a tubular anodised aluminium housing 12 having an open end 14 and a closed end 16, and a separate closure 18 for closing the

open end. The apparatus 10 further includes an electrode assembly 20 mountable on the closure 18 and pulse generating means in the form of an electronic circuit 30 (shown in figure 4) for energising the electrode assembly 20.

An inlet 22 to the housing is provided in the closed end 16 and an outlet 24 is defined in the closure 18. A passage 21 (shown in figure 7) extends from the inlet 22 to the outlet 24.

As best shown in figures 1 and 7, the electrode assembly 20 comprises an insulating disc or base 20.1 of an ozone and corona resistant material, such as glass, alumina etc and an annular electrode 20.2 mounted on the face of the base 20.1 facing away from the closure 18. The base 20.1 is provided with a plurality of spaced peripheral notches 20.3, the purpose of which will be described hereinafter.

The closure 18 is provided with an annular ridge formation 18.1. As best shown in figure 7, when the electrode assembly 20 is mounted on shoulder formations on the closure 18, the ridge formation 18.1 is disposed in close proximity, but with a clearance 23 of approximately 0.3mm from the base 20.1.

The aforementioned passage 21 extends from the inlet 22 along the tubular

housing 12, through the notches 20.3 in the base, through the clearance 23 between the ridge formation 18.1 and the base 20.1, and out via the outlet 24.

As will be described hereinafter, a rapidly changing electric field is established in the passage 21 in the region of the ridge formation 18.1 causing a corona discharge and oxygen flowing along the passage 21 in use, therefore passes through the field. The effect of the electric field is that instantaneous ionisation of oxygen is achieved by the corona discharge to produce ozone from the oxygen, without substantial energy loss in the form of heat generated.

The applicant has found that the ozone yield ratio is dependant on the rise time t_r, the fall time t_f and width w_p of the pulses 50 (shown in figure 5(d)) in the train 52 of pulses (shown in figure 6(d)) applied to the electrode assembly 20. It is believed that the shorter the rise and fall times and/or the pulse width, the more efficient the apparatus becomes.

A self-oscillating circuit 30 for energizing the electrode assembly 20 is shown in figure 4. Voltage waveforms as measured at points a, b, c and d are shown in figures 5(a), (b), (c) and (d) respectively and also in figures 6(a), (b), (c) and (d) respectively.

The circuit 30 comprises a capacitor 34 in parallel with a SIDAC 36 and inductor

37. The SIDAC is connected to the gate 39 of a field effect transistor (FET) such as a MOSFET 38 of the type IRF 740, for example. The SIDAC 36 conducts current when a voltage exceeding a certain threshold (100V for example) is applied across it. A primary winding of a transformer 43 is connected in the drain-source circuit 45 of the MOSFET 38. The secondary winding of the transformer is connected to the electrode assembly 20 as shown in figure 4.

A DC voltage of about 150V is applied at point 41 of the circuit. Initially the potential difference across the SIDAC 36 is insufficient to cause the SIDAC 36 to switch on and hence the capacitor 34 is charged up. When the voltage over the SIDAC 36 exceeds the aforementioned threshold voltage of the SIDAC 36, it switches on, resulting in a closed circuit from the capacitor 34 to the gate 39 of the MOSFET 38, partially discharging the capacitor 34 and hence charging the gate 39. The result is that a charge will now be shared between the capacitor 34 and the gate 39, so that some voltage, preferably sufficiently above the gate threshold voltage (typically 6V) relative to ground, is applied to the gate. The current that discharges from the capacitor 34 through to SIDAC 36 is applied to the gate 39 of the MOSFET 38 slightly prior to the onset of current flow in the drain-source circuit 45. As a result of the current from the capacitor, the voltage on the gate exceeds the aforementioned threshold voltage by a sufficient amount. The resulting signals at points a, b, c and d are shown in

figures 5(a) to (d) respectively and in figures 6(a) to (d), respectively.

Using this method, the gate voltage may for short intervals be driven approximately two to four times beyond the maximum threshold voltage rating of some MOSFETs without destroying the device.

As will be seen from figures 5(d) and 6(d) each of the pulses 50 in the train 52 of voltage pulses applied to the electrode assembly has a 30% - 70% slope or rise time t_r and a fall time t_f of better than 2kV/100ns, preferably in the order of 3kV/10ns. Furthermore, the width of the pulses w_p as they pass through the average value 54 is shorter than 100ns, preferably shorter than 30ns.

The peak value of the voltage applied to the electrode assembly is in the order of 3kV and with the clearance between the electrode 20.2 and the ridge 18 .1 in the order of 0.3mm, the maximum electric field strength E is bigger than 3kV/mm, preferably in the order of 10kV/mm.

Referring to figures 7 and 8, apparatus according to a second embodiment of the invention for producing ozone, is generally designated by reference numeral 100.

The basic working of the apparatus 100 is similar to that of apparatus 10, but

the construction of apparatus 100 differs in that the housing 102 is manufactured from an insulating material. The apparatus 100 includes a first electrode 104, which comprises a conductive annulus extending around the housing 102 and a second electrode 106 disposed inside the housing 102.

The second electrode 106 is provided with an annular ridge formation 106.1 disposed in close proximity to the inner wall of the housing 102, in the region of the first electrode 104. The first electrode 104 is connected to the self-oscillating circuit and the second electrode 106 is earthed. A corona discharge is therefore established between the ridge formation 106.1 and the inner wall of the housing 102, causing the production of ozone as hereinbefore described.

It will be appreciated that there are many variations in detail on the method and apparatus according to the invention without departing from the scope and spirit of the appended claims.